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# PERFORMANCE EVALUATION OF PCF AND DCF BASED WLANS FOR HETEROGENEOUS TRAFFIC APPLICATIONS

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## ABSTRACT

Wireless networks are one of the most popular networks in use for heterogeneous application traffics owing to their economy and easier deployment. In this paper, we have evaluated performance of wireless local area networks using different performance parameters, with the aim to study the impact of PCF and DCF based schemes for heterogeneous type of traffic using OPNET. It is observed that PCF based scheme offers lesser delay for all kinds of traffic applications, while DCF based systems support better throughput.

**KEYWORDS:** WLANs, Heterogeneous Networks, DCF, PCF, Throughput

## INTRODUCTION

IEEE 802.11 Wireless LANs (WLAN) have been widely deployed over the last few years owing to their ease of implementation and cost effectiveness. Owing to their widespread popularity in commercial usage, research activities have intensified, and major focus has been put on the medium access control (MAC) layer as it plays a crucial role in the design of Wireless LAN. The MAC sub-layer ensures that only one device can transmit on any type of media at any time. WLAN applications are mainly data centric though there is growing demand for real time services over these networks. The IEEE 802.11 standard has defined two different access mechanisms in order to allow multiple users to access common channel viz. (i) distributed coordination function (DCF) and (ii) the point coordination function (PCF), which is a centrally controlled access mechanism. The following three basic access mechanisms have been defined for IEEE 802.11: (i) the basic access method based on CSMA/CA, (ii) an optional method avoiding hidden terminal problem, and (iii) a contention-free polling method for time bounded services. The first two methods are also summarized as Distributed Coordination Function (DCF); the third method is called Point Coordination Function (PCF).

In DCF, data frames are transmitted via -(i) basic access mechanism and (ii) request-to-send /clear-to-send (RTS/CTS) mechanism. In Basic Access Mechanism, channel remains idle for a period of time Distribution Inter Frame Space (DIFS). The Station generates random back off interval and employs discrete-time back off scale. The transmission takes at the beginning of time slot. The RTS/CTS mechanism reserves the medium before transmitting a data frame by transmitting an RTS frame and replying with a CTS frame. Another coordination function i.e. PCF is available only in "infrastructure" mode, where stations are connected to the network through an Access Point (AP). In this, the time is divided into contention period (CP) and contention free period (CFP). During CP, transfer uses DCF, i.e., Data-ACK, or RTS-CTS Data-ACK, with exponential back-off etc; whereas during CFP, the Access Point (AP) controls all transmissions like- which station transmits to the AP and which station receives packets from the AP. All stations can receive packets during the CFP. But the ability to transmit during the CFP is optional. This paper analyses the performance of WLAN, using DCF and PCF based schemes, for heterogeneous type of traffic like voice, video and FTP. The performance is measured quantitatively in terms of throughput and delay using OPNET MODELER 14.0.

## RELATED WORK

Wireless network is described by two MAC schemes, the mandatory DCF and the optional PCF. Researchers have tried to characterize WLANs behavior in transmitting mixed traffic. It was gathered that tuning the CFP and super frame size dynamically achieve better end to end delay and throughput profiles as shown in [1]. The PCF, as opposed to DCF, was designed to support time bounded traffic. It uses a centralized polling based channel access method which best supports time bounded services as shown by Rasheed et al [2].Their results showed that PCF-based workstations perform more efficiently than DCF-based workstations. In IEEE 802.11 DCF networks, a packet is discarded if the maximum number of retransmission attempts is reached and the impact of retry limit on throughput performance was studied in [3]. It was shown that the maximum throughput is independent of the retry limit. To improve the throughput performance the initial back off window size should be carefully tuned according to the value of retry limit. At which point it makes sense for best effort, real time and mixed traffic scenarios to switch from DCF to PCF mode, was studied by Kopsel et al [5]. The results showed that the DCF mode is useful for low traffic and less number of mobile scenarios and PCF function is used for high load scenarios. OPNET Modeler [4] [6] is used to simulate the RTS/CTS mechanism to evaluate the performance of IEEE 802.11 MAC protocol in [7]. Jasani and Alaraje simulated the scenarios with and without RTS/CTS mechanism enabled on network nodes [8]. By comparing the total WLAN retransmission, data traffic sent/received, WLAN delay of two scenarios, it was concluded that the RTS/CTS mechanism is helpful to reduce the number of retransmissions if hidden node problem persists in network scenarios. The performance of MAC protocol was analyzed in [9] by processing of fragmented and un-fragmented data, with and without handshaking mechanism, and by varying the channel capacity at physical layer in Ad hoc and infrastructure-based network using OPNET Modeler. The results showed that network saturation degrades the performance and smaller packet size of data traffic gives better results. Increasing the number of fragments of the MAC service data unit (MSDU) increases the overall delay and reduces the throughput of the network. The paper is organized as follows- Next section describes the simulation setup for the WLAN and various traffic applications. Section IV presents the comparative performance analysis for the PCF and DCF schemes along with some concluding remarks.

**Table 1: System Simulation Description**

| Physical Characteristics | 802.11b (Direct Sequence) |
|---|---|
| Data rate | 11Mbps |
| Type of traffic | Voice, Video and FTP |
| MAC Layer | PCF and DCF |
| Performance metrics | Delay and Throughput |
| Simulation area | 10*10 km |
| Simulation time | 600 secs |
| Simulator | OPNET-Modeler 14.0 |

## SIMULATION SET-UP

To analyze and study the WLAN performance in this work, a network model with 20 nodes was developed. Two scenarios are modeled for voice, video, and ftp traffic with PCF and DCF based schemes to analyze Delay and Throughput performance metric.

**Table 2: Simulation Parameters for Video Traffic**

| Attribute | Value |
|---|---|
| Inter request time(seconds) | Exponential(360) |
| Frame size(bytes) | Constant 50000 |
| Physical layer technology | Direct sequence |
| Data rate | 11 mbps |

The system simulation description is shown in Table 1. The attributes and parameters for heterogeneous type of traffic (video, voice and ftp) are shown in Table 2, 3 and 4 respectively**.**

**Table 3: Simulation Parameter for Voice Traffic**

| Attribute | Value |
|---|---|
| Frame rate | 15 frames/sec |
| Frame size | 128*240 pixel |
| Physical layer technology | Direct sequence |
| Data rate | 11mbps |

**Table 4: Simulation Parameter for FTP Traffic**

| Attribute | Value |
|---|---|
| Voice frame per packet | 1 |
| Encoder scheme | G.729 A(Silence) |
| Physical layer technology | Direct sequence |
| Data rate | 11 mbps |

## PERFORMANCE ANALYSIS AND COMPARISON

In this section the performance of the PCF and DCF based schemes for the simulated network are analyzed and compared for the heterogeneous traffic application pertaining to FTP non-real-time FTP, and real-time voice and video traffic applications.

### Scenario 1

Firstly, the 20 node size WLAN for transmitting heterogeneous traffic (video, voice and ftp) was simulated and the results in terms of Delay were observed as shown in Figure 1 and Figure 2 for the PCF and DCF based schemes respectively. It is observed from Figure 1 that the delay parameter is minimum for FTP traffic followed by voice and then video using PCF scheme. For the DCF based scheme, the Delay rating is FTP followed by video and then voice. Further, in comparison to DCF, the PCF based scheme offers overall less delay for all kinds of traffic applications. In DCF, transmission of frames is distributed to all the stations whereas in PCF transmission of frames is synchronous between access point and the stations. Furthermore, it was observed that for voice traffic in DCF, the delay tends to increase and did not stabilize.

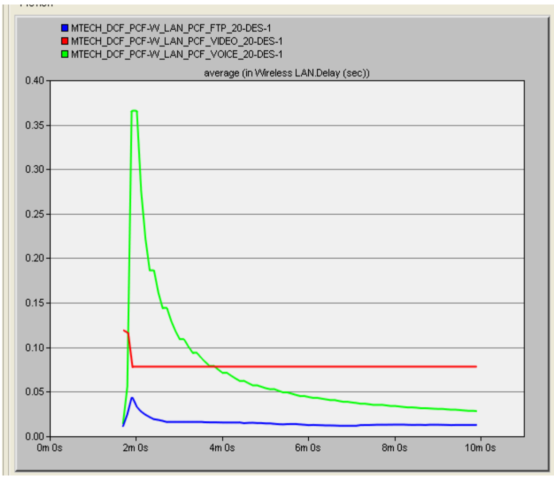


**Figure 1: Performance in Terms of Delay for PCF Based WLAN with Node Size=20**

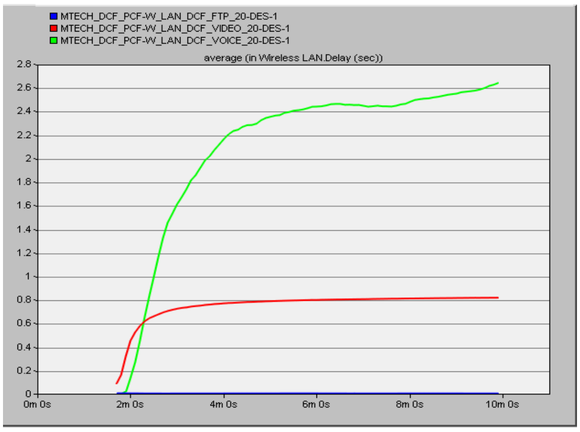


**Figure 2: Performance in Terms of Delay for DCF Based WLAN with Node Size=20**

**Scenario 2**

In this scenario, the performance in terms of Throughput is observed for heterogeneous type of traffic (video, voice and ftp) for 20 nodes WLAN with PCF and DCF based schemes. As shown in Figure 3, the throughput is minimum for Video followed by Voice and then for FTP using PCF; whereas, for DCF model (Figure 4), the ratings are FTP followed by Voice and then Video. Further, in comparison to PCF, the DCF based system supports better throughput for all applications indicating better channel utilization in distributive scenario (Table 5). For video traffic, however, the throughput tends to increase over time indicating suitability of using DCF for video communication.

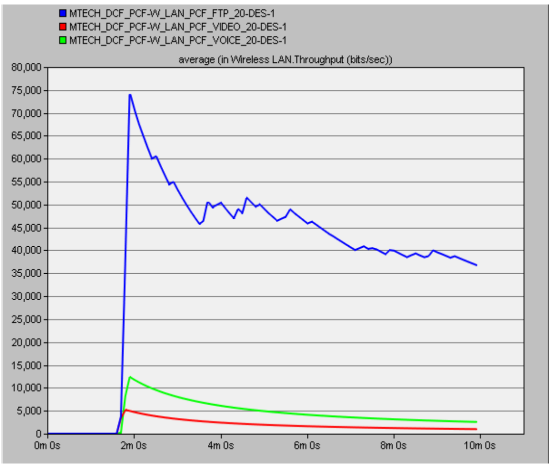


**Figure 3: Performance in Terms of Throughput for PCF Based WLAN with Node Size=20**

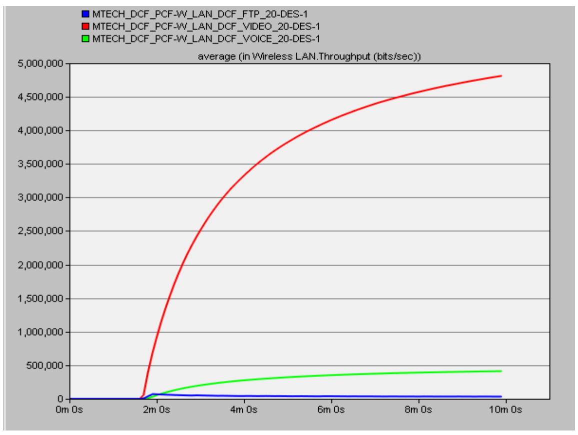


**Figure 4: Performance in Terms of Throughput for DCF Based WLAN with Node Size=20**

The logic being DCF is a distributed algorithm where all the stations equally participate in taking the needful decisions in regards to exploring the possibility of alternate available paths but in PCF, coordination is achieved by a single centralized access point running a centralized algorithm. PCF tends to reduce overall throughput due to the adopted polling mechanism.

**Table 5: Performance Comparison for PCF and DCF Based WLAN with # Nodes=20**

| Traffic Type | PCF | | DCF | |
|---|---|---|---|---|
| | Delay (Sec) | Throughput (Bits/Sec) | Delay (Sec) | Throughput (Bits/Sec) |
| FTP | 0.02 | 35000-40000 | 0 | 100,000 |
| Voice | 0.03 | 3000 | 2.6 | 400,000 |
| Video | 0.08 | 2000 | 0.8 | 4700,000 |

The performance comparison between the two schemes is shown in Table 5. As reflected from it, for the tested network scenarios, DCF based WLAN supports better throughput for the tested voice, video and FTP traffic rates as compared to PCF. PCF degrades the overall throughput due to the adopted polling mechanism which tends to reduce the channel utilization. End to End delay, in general, is more for voice and video in comparison to FTP. Further, PCF based WLAN are found to offers lesser delay than DCF for the real-time or time bound traffic applications for the tested network set-up as the chances of contention and centralized overhead are lesser in it.

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